Simulations of Transcutaneous Energy Transmitters by using Homogenization Method

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Transcutaneous Energy Transmitters (TET) are wireless devices to transfer energy from outside the body to inside the body. They use inductive coupling between a primary coil external to the body and a secondary coil underneath the skin, similar to a coreless transformer (T. D. Dissanavake, A. P. Hu, S. Malpas, L. Bennet, A. Taberner, L. Booth, and D. Budgett "Experimental Study of a TET System for Implantable Biomedical Devices", in *IEEE Transactions on Biomedical Circuits and Systems*, vol. 3, no. 6, 2009). Usually, a TET comprises a pair of single layer pancake coils, which are difficult to align. The effect of a possible misalignment has to be considered during the early design stages by e.g. Finite element (FE) simulations. A computationally expensive 3D FE model is required though, especially at high frequencies when accurately accounting for eddy current effects implies considering solid massive conductors. Indeed, taking into account that the TET may consider a wide frequency range with different wire gauge radii, the skin and proximity effects cannot be ignored. Thus, the use of the stranded model is not accurate enough in this case. Several works use the stranded model ignoring these effects and estimating the Joule losses a posteriori.

However, the eddy current effects may significantly alter the TET performance and their direct inclusion in the FE simulations is mandatory. Dedicated homogenization methods thus prove essential. In the frequency domain, they usually amount to the use of complex frequency-dependent reluctivity and resistance values, the expression of which is obtained analytically, or using an elementary FE model. Several authors have dealt with these methods in the frequency domain (J. Gyselinck, and P. Dular. "Frequency-domain homogenization of bundles of wires in 2D magneto dynamic FE calculations" in *IEEE Transactions On Magnetics*, vol. 41, pp. 1416-1419, 2005) and the time domain (R. V. Sabariego, P. Dular, and J. Gyselinck. "Time-Domain Homogenization of Windings in 3-D Finite Element Models" in *IEEE Transactions On Magnetics*, vol. 44, pp. 1302-1305, 2008), to study a multi-turn typical winding inductor, what has homogeneous geometry. Here, a homogenization method is applied to study the single layer coils from the TET with a 3D FE model in the frequency domain. Results will be compared with both the stranded approach and experimental measurements, showing that the homogenization method is very reliable even for single layer pancake coils, where the geometry is not so homogeneous.